

WHAT IS CLAIMED IS:

1. An information transmission system for transmitting information from a sending apparatus to
5 a receiving apparatus, said information transmission system comprising:

a sending apparatus for modulating an information signal, generating a plurality of signals including an optical signal from said
10 information signal which is modulated, and transmitting said plurality of signals via a plurality of routes; and

a receiving apparatus for receiving said plurality of signals from said sending apparatus,
15 combining said plurality of signals, and outputting said information signal.

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2. The information transmission system as claimed in claim 1, wherein said plurality of signals are a plurality of optical signals or signals including a radio signal.

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3. An information transmission method used
30 for transmitting information from a sending apparatus to a receiving apparatus, said information transmission method comprising the steps of:

a sending apparatus modulating an information signal, generating a plurality of
35 signals including an optical signal from said information signal which is modulated, and transmitting said plurality of signals; and

a receiving apparatus receiving said plurality of signals from said sending apparatus, combining said plurality of signals, and outputting said information signal.

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4. The information transmission method as claimed in claim 3, wherein said plurality of signals are a plurality of optical signals or signals including a radio signal.

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5. An optical space transmission system comprising:

a first optical space transmission apparatus including one or more optical transmitters which send a radio modulation signal converted from an information signal; and

a second optical space transmission apparatus including one or more optical receivers which combine a plurality of receive signals transmitted by said first optical space transmission apparatus via a plurality of paths.

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6. The optical space transmission system as claimed in claim 5, wherein said one or more optical transmitters send said radio modulation signal a plurality of times by shifting sending time, and said plurality of receive signals are transmitted via a plurality of paths with respect to

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time or space.

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7. An optical space transmission system comprising:

10 a first optical space transmission apparatus including a radio signal modulation part which converts an information signal to be sent into a radio modulation signal, and an optical transmitter which converts output of said radio signal modulation part into an optical signal; and
15 a second optical space transmission apparatus including a plurality of optical receivers which convert optical signals received from said optical transmitter into electrical signals, and a diversity radio signal processing part which combines outputs of said optical receivers.

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25 8. An optical space transmission system comprising:

a first optical space transmission apparatus including a radio signal modulation part which converts an information signal to be sent into a radio modulation signal, a part which divides
30 output of said radio signal modulation part into a plurality of branches, and a plurality of optical transmitters which converts signals of said branches into optical signals and transmit said optical signals to the air; and
35 a second optical space transmission apparatus including an optical receiver which receives said optical signals sent from said optical

transmitters and converts said optical signals into electrical signals, and a radio signal processing part which equalizes and combines output of said optical receiver.

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9. An optical space transmission system
10 comprising:

a first optical space transmission
apparatus including a part which divides an
information signal to be sent into a plurality of
branches, a plurality of radio signal modulation
15 parts which convert signals of said branches into
radio modulation signals, and a plurality of optical
transmitters which converts outputs of said radio
signal modulation parts into optical signals and
transmit said optical signals to the air; and

20 a second optical space transmission
apparatus including an optical receiver which
receives said optical signals sent from said optical
transmitters and converts said optical signals into
electrical signals, and a radio signal processing
25 part which equalizes and combines output of said
optical receiver.

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10. An optical space transmission system
comprising:

a first optical space transmission
apparatus including a radio signal modulation part
35 which converts an information signal to be sent into
a radio modulation signal, a part which divides
output of said radio signal modulation part into a

plurality of branches, and a plurality of optical transmitters which converts signals of said branches into optical signals and transmits said optical signals to the air; and

5 a second optical space transmission apparatus including a plurality of optical receivers which receive said optical signals sent from said optical transmitters and convert said optical signals into electrical signals, and a diversity
10 radio signal processing part which equalizes and combines outputs of said optical receivers.

15 11. An optical space transmission system comprising:

 a first optical space transmission apparatus including a part which divides an
20 information signal to be sent into a plurality of branches, a plurality of radio signal modulation parts which convert signals of said branches into radio modulation signals, and a plurality of optical transmitters which convert outputs of said radio
25 signal modulation parts into optical signals and transmit said optical signals to the air; and

 a second optical space transmission apparatus including a plurality of optical receivers which receive said optical signals sent from said
30 optical transmitters and convert said optical signals into electrical signals, and a diversity radio signal processing part which equalizes and combines outputs of said optical receivers.

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12. The optical space transmission system
as claimed in claim 8, said first optical space
transmission apparatus including at least a delay
circuit which delays a part of signals of said
5 branches.

10 13. The optical space transmission system
as claimed in claim 9, said first optical space
transmission apparatus including at least a delay
circuit which delays a part of signals of said
branches.

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14. An optical space transmission system
20 comprising:
a first optical space transmission
apparatus including a radio signal modulation part
which converts an information signal to be sent into
a radio modulation signal, a part which divides
25 output of said radio signal modulation part into a
plurality of branches, one or more delay circuits
which delay a part of signals of said branches, a
multiplexer which multiplexes output of said delay
circuits and signals of the other branches, and an
30 optical transmitter which converts output of said
multiplexer into an optical signal and transmits
said optical signal to the air; and

a second optical space transmission
apparatus including an optical receiver which
35 receives said optical signal sent from said optical
transmitter and converts said optical signal into an
electrical signal and a radio signal processing part

which equalizes and combines output of said optical receiver.

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15. The optical space transmission system as claimed in claim 7, said radio signal modulation part in said first optical space transmission
10 apparatus including a baseband modulation part, and an orthogonal modulation part which orthogonally modulates output of said baseband modulation part.

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16. The optical space transmission system as claimed in claim 15, said radio signal modulation part further including a frequency converter after
20 said orthogonal modulation part, and a local oscillator which generates a reference signal for said frequency converter.

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17. The optical space transmission system as claimed in claim 8, said radio signal processing part in said second optical space transmission
30 apparatus comprising:
an orthogonal detection part which detects baseband radio modulation signals sent from said first optical space transmission apparatus;
an equalizer which equalizes and combines
35 output of said orthogonal detection part; and
a baseband demodulation part which converts output of said equalizer into an original

information signal.

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18. The optical space transmission system as claimed in claim 9, said radio signal processing part in said second optical space transmission apparatus comprising:

- 10 an orthogonal detection part which detects baseband radio modulation signals sent from said first optical space transmission apparatus;
- an equalizer which equalizes and combines output of said orthogonal detection part; and
- 15 a baseband demodulation part which converts output of said equalizer into an original information signal.

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19. The optical space transmission system as claimed in claim 8, said radio signal processing part in said second optical space transmission apparatus comprising:

- 25 a frequency converter which converts radio modulation signals of intermediate frequency band or radio frequency band sent from said first optical space transmission apparatus into baseband;
- 30 a local oscillator which generates a reference signal for said frequency converter;
- an orthogonal detection part which detects baseband radio modulation signals output from said frequency converter;
- 35 an equalizer which equalizes and combines output of said orthogonal detection part; and
- a baseband demodulation part which

converts output of said equalizer into an original information signal.

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20. The optical space transmission system as claimed in claim 9, said radio signal processing part in said second optical space transmission apparatus comprising:

10 a frequency converter which converts radio modulation signals of intermediate frequency band or radio frequency band sent from said first optical space transmission apparatus into baseband;

15 a local oscillator which generates a reference signal for said frequency converter;

an orthogonal detection part which detects baseband radio modulation signals output from said frequency converter;

20 an equalizer which equalizes and combines output of said orthogonal detection part; and

a baseband demodulation part which converts output of said equalizer into an original information signal.

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21. The optical space transmission system as claimed in claim 7, said diversity radio signal processing part in said second optical space transmission apparatus comprising:

30 a plurality of orthogonal detection parts which detect baseband signals received by said

35 optical receivers;

a baseband diversity equalization combining part which combines outputs of said

orthogonal detection parts; and

a baseband demodulation part which
converts output of said baseband diversity
equalization combining part into an original
5 information signal.

10 22. The optical space transmission system
as claimed in claim 7, said diversity radio signal
processing part in said second optical space
transmission apparatus comprising:

a diversity combining part which combines
15 signals of intermediate frequency band or radio
frequency band received by said optical receivers;

a frequency converter for output of said
diversity combining part;

a local oscillator which generates a
20 reference signal for said frequency converter;

an orthogonal detection part which detects
baseband radio modulation signals output from said
frequency converter;

an equalizer which equalizes and combines
25 output of said orthogonal detection part; and

a baseband demodulation part which
converts output of said equalizer into an original
information signal.

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23. The optical space transmission system
as claimed in claim 7, said diversity radio signal
35 processing part in said second optical space
transmission apparatus comprising:

a plurality of frequency converters which

perform frequency conversion for signals of intermediate frequency band or radio frequency band received by said optical receivers;

5 a local oscillator which generates a reference signal for said frequency converters;

a plurality of orthogonal detection parts which detect baseband signals output from said frequency converters;

10 a baseband diversity equalization combining part which combines outputs of said orthogonal detection parts; and

15 a baseband demodulation part which converts output of said baseband diversity equalization combining part into an original information signal.

20 24. The optical space transmission system as claimed in claim 22, said diversity combining part comprising a part which performs maximum ratio combining for a plurality of input signals.

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25. The optical space transmission system as claimed in claim 22, said diversity combining
30 part comprising a part which performs selection combining for a plurality of input signals according to receive level.

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26. The optical space transmission system

as claimed in claim 22, said diversity combining part comprising a part which performs equal gain combining for a plurality of input signals.

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27. The optical space transmission system as claimed in claim 21, said baseband diversity equalization combining part comprising:
10 transversal equalizers which equalize input baseband signals; and
a part for performing maximum ratio combining for outputs of said transversal equalizers.

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28. The optical space transmission system as claimed in claim 21, said baseband diversity equalization combining part comprising:
20 transversal equalizers which equalize input baseband signals; and
a part for performing selection combining
25 for outputs of said transversal equalizers.

29. The optical space transmission system as claimed in claim 21, said baseband diversity equalization combining part comprising:
30 transversal equalizers which equalize input baseband signals; and
35 a part for performing equal gain combining for outputs of said transversal equalizers.

30. The optical space transmission system
5 as claimed in claim 21, said baseband diversity
equalization combining part comprising an adaptive
decision feedback type transversal combining
diversity part.

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31. The optical space transmission system
as claimed in claim 30, wherein said adaptive
15 decision feedback type transversal combining
diversity part uses an adaptive algorithm for
determining tap coefficients of said transversal
equalizers.

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32. The optical space transmission system
as claimed in claim 31, wherein RLS algorithm is
25 used as said adaptive algorithm.

33. The optical space transmission system
30 as claimed in claim 31, wherein LMS algorithm is
used as said adaptive algorithm.

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34. An optical space transceiver

comprising a first optical space transmission apparatus and a second optical space transmission apparatus;

5 said first optical space transmission apparatus including one or more optical transmitters which send an information signal converted into a radio modulation signal; and

10 said second optical space transmission apparatus including one or more optical receivers which combines a plurality of receive signals sent via a plurality of paths.

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35. An optical space transmission method comprising the steps of:

20 converting an information signal to be sent into a radio modulation signal, and sending said radio modulation signal as an optical signal in a sending station;

25 receiving optical signals, converting said optical signals into electrical signals, and demodulating said electrical signals by performing equalization and combining or by performing diversity combining in a receiving station.

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36. An optical space transmission apparatus having one or more optical transmitters in an optical space transmission system which includes said optical space transmission apparatus having one or more optical transmitters and an optical space transmission apparatus having one or more optical receivers, wherein:

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said optical space transmission apparatus having one or more optical transmitters includes one or more radio signal modulation parts which converts an information signal into one or more radio modulation signals.

37. The optical space transmission apparatus as claimed in claim 36, wherein said one or more optical transmitters send said radio modulation signal a plurality of times by shifting sending time.

38. An optical space transmission apparatus having one or more optical receivers in an optical space transmission system which includes an optical space transmission apparatus having one or more optical transmitters and said optical space transmission apparatus having one or more optical receivers, wherein:

said optical space transmission apparatus having one or more optical receivers receives signals transmitted via a plurality of paths by said optical space transmission apparatus having one or more optical transmitters, combines said signals transmitted via a plurality of paths.

39. The optical space transmission apparatus as claimed in claim 38, wherein said one

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a radio signal modulation part for

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said receiving apparatus comprising:

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an optical signal receiver for receiving

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a signal combining part for combining said first signal and said second signal, and regenerating said information signal.

41. The information transmission system as
5 claimed in claim 40, said sending apparatus further
comprising:

a signal dividing part for dividing said
information signal into a first signal part and a
second signal part;

10 wherein said radio signal transmitter
transmits said first signal part to said receiving
apparatus as a radio signal, and said optical signal
transmitter transmits said second signal part to
said receiving apparatus as an optical signal.

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42. An information transmission system for
20 transmitting information from a sending apparatus to
a receiving apparatus, said information transmission
system comprising said sending apparatus and said
receiving apparatus which include a mode selection
part for selecting one of a first transmission mode
25 and a second transmission mode,

said sending apparatus comprising:

a signal dividing part for dividing an
information signal into a first signal part and a
second signal part;

30 radio signal modulation parts for
modulating said first signal part and said second
signal part;

a control part for controlling said
sending apparatus such that said first signal part
35 is transmitted to said receiving apparatus as a
radio signal and said second signal part is
transmitted to said receiving apparatus as an

optical signal when said first transmission mode is selected;

5 said control part controlling said sending apparatus such that said information signal is transmitted to said receiving apparatus via a plurality of routes including a radio transmission route and an optical transmission route when said second transmission mode is selected,

10 said receiving apparatus comprising:
a part for multiplexing said first signal part and said second signal part when said first transmission mode is selected; and

15 a part for diversity-combining said information signal which is transmitted via said plurality of routes when said second transmission mode is selected.

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43. The information transmission system as claimed in claim 42, wherein said mode selection part selects said first transmission mode when transmission routes between said sending apparatus and said receiving apparatus are in a first condition, and said mode selection part selects said second transmission mode when said transmission routes between said sending apparatus and said receiving apparatus are in a second condition which is worse than said first condition.

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35 44. The information transmission system as claimed in claim 40, said radio signal modulation part including a baseband modulation part, and an

orthogonal modulation part which orthogonally modulates output of said baseband modulation part.

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45. The information transmission system as claimed in claim 44, said radio signal modulation part further including a frequency
10 converter after said orthogonal modulation part, and a local oscillator which generates a reference signal for said frequency converter.

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46. The information transmission system as claimed in claim 40, said signal combining part in said receiving apparatus comprising:

20 a plurality of orthogonal detection parts which detect baseband signals received by said optical signal receiver;

a baseband diversity equalization combining part which combines outputs of said
25 orthogonal detection parts; and

a baseband demodulation part which converts output of said baseband diversity equalization combining part into an original information signal. .

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47. The information transmission system as
35 claimed in claim 40, said signal combining part in said receiving apparatus comprising:

a diversity combining part which combines

signals of intermediate frequency band or radio frequency band received by said optical receivers;

a frequency converter for output of said diversity combining part;

5 a local oscillator which generates a reference signal for said frequency converter;
an orthogonal detection part which detects baseband radio modulation signals output from said frequency converter;

10 an equalizer which equalizes and combines output of said orthogonal detection part; and

a baseband demodulation part which converts output of said equalizer into an original information signal.

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48. The information transmission system as claimed in claim 40, said signal combining part in said receiving apparatus comprising:

a plurality of frequency converters which perform frequency conversion for signals of intermediate frequency band or radio frequency band received by said optical receivers;

25 a local oscillator which generates a reference signal for said frequency converters;

a plurality of orthogonal detection parts which detect baseband signals output from said frequency converters;

30 a baseband diversity equalization combining part which combines outputs of said orthogonal detection parts; and

a baseband demodulation part which converts output of said baseband diversity equalization combining part into an original information signal.

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5 49. The information transmission system as
claimed in claim 47, said diversity combining part
comprising a part which performs maximum ratio
combining for a plurality of input signals.

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50. The information transmission system as
claimed in claim 47, said diversity combining part
15 comprising a part which performs selection combining
for a plurality of input signals according to
receive level.

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51. The information transmission system as
claimed in claim 47, said diversity combining part
comprising a part which performs equal gain
25 combining for a plurality of input signals.

30 52. The information transmission system as
claimed in claim 46, said baseband diversity
equalization combining part comprising:
transversal equalizers which equalize
input baseband signals; and
35 a part for performing maximum ratio
combining for outputs of said transversal equalizers.

uses an adaptive algorithm for determining tap coefficients of said transversal equalizers.

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57. The information transmission system as claimed in claim 56, wherein RLS algorithm is used as said adaptive algorithm.

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58. The information transmission system as claimed in claim 56, wherein LMS algorithm is used as said adaptive algorithm.

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59. An information transmission method used for transmitting information from a sending apparatus to a receiving apparatus, said information transmission method comprising the steps of:

25 said sending apparatus modulating an information signal, transmitting said information signal which is modulated to said receiving apparatus via a plurality of routes as a radio signal and an optical signal;

30 said receiving apparatus receiving said radio signal transmitted from said sending apparatus and outputting a first signal, and receiving said optical signal transmitted from said sending apparatus and outputting a second signal; and

35 said receiving apparatus combining said first signal and said second signal, and regenerating said information signal.

5 60. The information transmission method as
claimed in claim 59, said information transmission
method further comprising the steps of:

 said sending apparatus dividing said
information signal into a first signal part and a
10 second signal part;

 wherein said sending apparatus transmits
said first signal part to said receiving apparatus
as a radio signal, and transmits said second signal
part to said receiving apparatus as an optical
15 signal.

20 61. An information transmission method
used for transmitting information from a sending
apparatus to a receiving apparatus, said information
transmission method comprising the steps of:

 selecting one of a first transmission mode
25 and a second transmission mode,

 said sending apparatus dividing an
information signal into a first signal part and a
second signal part, modulating said first signal
part and said second signal part;

30 controlling said sending apparatus such
that said first signal part is transmitted to said
receiving apparatus as a radio signal and said
second signal part is transmitted to said receiving
apparatus as an optical signal when said first
35 transmission mode is selected;

 controlling said sending apparatus such
that said information signal is transmitted to said

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receiving apparatus via a plurality of routes including a radio transmission route and an optical transmission route when said second transmission mode is selected;

5 said receiving apparatus multiplexing said first signal part and said second signal part when said first transmission mode is selected; and

 said receiving apparatus diversity-combining said information signal which is
10 transmitted via said plurality of routes when said second transmission mode is selected.

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62. The information transmission method as claimed in claim 61, wherein said first transmission mode is selected when transmission routes between said sending apparatus and said receiving apparatus
20 are in a first condition, and said second transmission mode is selected when said transmission routes between said sending apparatus and said receiving apparatus are in a second condition which is worse than said first condition.

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63. A sending apparatus comprising:
30 a radio signal modulation part for modulating an information signal;

 a radio signal transmitter for transmitting said information signal which is modulated as a radio signal; and

35 an optical signal transmitter for transmitting said information signal which is modulated as an optical signal.

5 64. The sending apparatus as claimed in
claim 63, said sending apparatus further comprising:
 a signal conversion part for converting
said information signal which is modulated to a
radio signal of an intermediate frequency band;
10 a frequency conversion part for converting
frequency band of said radio signal to a radio
frequency band;
 an optical signal conversion part for
converting said radio signal of said intermediate
15 frequency band to an optical signal.

20 65. The sending apparatus as claimed in
claim 63, said sending apparatus further comprising:
 a digital signal conversion part for
converting said information signal to a digital
signal;
25 an analog signal converter for converting
said digital signal into a radio signal of an analog
signal format; and
 an optical signal conversion part for
converting said digital signal to an optical signal.
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35 66. The sending apparatus as claimed in
claim 63, said sending apparatus further comprising:
 a signal dividing part for dividing said
information signal into a first signal part and a

wherein said radio signal transmitter transmits said first signal part as a radio signal, and said optical signal transmitter transmits said second signal part as an optical signal.

15 a signal dividing part for dividing an
information signal into a first signal part and a
second signal part;

20 a control part for controlling said
sending apparatus such that said first signal part
is transmitted as a radio signal and said second
signal part is transmitted as an optical signal when
said first transmission mode is selected;

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68. The sending apparatus as claimed in
35 claim 67, wherein said mode selection part selects
said first transmission mode when transmission
routes between said sending apparatus and a

receiving apparatus at the other end are in a first condition, and said mode selection part selects said second transmission mode when said transmission routes are in a second condition which is worse than
5 said first condition.

10 69. A receiving apparatus comprising:
a radio signal receiver for receiving a radio signal and outputting a first signal;
an optical signal receiver for receiving an optical signal and outputting a second signal;
15 and
a signal combining part for combining said first signal and said second signal, and regenerating said information signal.

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70. The receiving apparatus as claimed in claim 69, said receiving apparatus further
25 comprising:

a mode selection part for selecting one of a first transmission mode and a second transmission mode;
wherein said first signal and said second
30 signal are multiplexed when said first transmission mode is selected, and said first signal and said second signal are diversity-combined by said signal combining part when said second transmission mode is selected.

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71. The receiving apparatus as claimed in
claim 70, wherein said mode selection part selects
said first transmission mode when transmission
5 routes between said sending apparatus and said
receiving apparatus are in a first condition, and
said mode selection part selects said second
transmission mode when said transmission routes
between said sending apparatus and said receiving
10 apparatus are in a second condition which is worse
than said first condition.

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